(4)

TGAL-89-03

CENTER FOR SEISMIC STUDIES
FINAL REPORT
PHASE III

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Teledyne Geotech
314 Montgomery Street
Alexandria, Virginia 22314-1581

JUNE 1986

ARPA ORDER NO: 4198

PROJECT TITLE: Installation, Maintenance, Operation, and Development Support for a Prototype Seismic Data Center

CONTRACT: MDA903-82-C-0063

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Prepared for:
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
1400 Wilson Boulevard
Arlington, VA 22209

Monitored by:
DEFENSE SUPPLY SERVICE-WASHINGTON
Room 1D245, Pentagon
Washington, D.C. 20310

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188
Exp. Date: Jun 30, 1986

1a REPORT SECURITY CLASSIFICATION: Unclassified	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for Public Release; Distribution Unlimited
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S): TGAL-89-03	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION: Teledyne Geotech Alexandria Laboratories; 6b OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION: Defense Supply Service - Washington
6c ADDRESS (City, State, and ZIP Code): 314 Montgomery Street Alexandria, VA 22314	7b ADDRESS (City, State, and ZIP Code): Room 1D-245, The Pentagon Washington, D.C. 20310
8a NAME OF FUNDING/SPONSORING ORGANIZATION: DARPA; 8b OFFICE SYMBOL (If applicable): NMRO	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: MDA903-82-C-0063
8c ADDRESS (City, State, and ZIP Code): 1400 Wilson Boulevard Arlington, VA 22209	10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO.; PROJECT NO. 4198; TASK NO.; WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification): Installation, Maintenance, Operation, and Development Support for a Prototype Seismic Data Center

12 PERSONAL AUTHOR(S): P. Kovacs, R. Perez, W. Whyte

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final Technical Report	FROM Feb 84 TO May 86	1989, March, 15	23

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Seismology, RSTN Network, Data Center, VAX Computer

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This report summarizes the activities and work performed at the Center for Seismic Studies, during the period beginning February 1, 1984, through April 30, 1986. This 27-month period was the third and final phase of the 53-month contract which began on December 1, 1981. Earlier phases had established the facility, brought in and installed computer systems, and implemented software to process routinely real-time and other types of seismic data. The objectives of this final phase were to continue the routine cataloging and building of the databases and support development of the data management and seismic data analysis techniques.

The objective of receiving and storing seismic data were met as the databases increased in volume from the routine processing accomplished by the analysts and the operational staff. The primary confiugration changes to the systems during this phase were to move the satellite antenna from the Alexandria Laboratory facility to the roof

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION
☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL: Ms. Ann Kerr	22b TELEPHONE (Include Area Code): (202) 697-7522; 22c OFFICE SYMBOL: DARPA/NMRO

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

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ABSTRACT

This report summarizes the activities and work performed at the Center for Seismic Studies during the period beginning February 1, 1984, through April 30, 1986. This 27-month period was the third and final phase of the 53-month contract which began on December 1, 1981. Earlier phases had established the facility, brought in and installed computer systems, and implemented software to process routinely real-time and other types of seismic data. The objectives of this final phase were to continue the routine cataloging and building of the databases and support development of the data management and seismic data analysis techniques.

The objectives of receiving and storing seismic data were met as the databases increased in volume from the routine processing accomplished by the analysts and the operational staff. The primary configuration changes to the systems during this phase were to move the satellite antenna from the Alexandria Laboratory facility to the roof of the Center in Rosslyn, Virginia. Another satellite antenna was installed to accept real-time data transmitted from the NORESS array. The installation of these antennae took considerable effort and co-ordination.

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INTRODUCTION

This final report summarizes the work performed at the Center For Seismic Studies in Rosslyn, Virginia, during the period February 1, 1984, through April 30, 1986. The activities described here were accomplished under Contract MDA903-82-C-0063, and this report fulfills Data Item 0002AH of the Report Requirements in that contract.

The objectives of this contract were 1) routine cataloging and building of the seismic databases; and 2) support for new data management and seismic data analysis techniques.

Section II of this report discusses system improvements and upgrades. During this period new equipment was acquired to enhance the systems capabilities and increase data throughput. Also discussed is the installation of dish antennae on the roof of the Center for data acquisition. In Section III, we briefly discuss the routine data acquisition at the Center. Section IV discusses the activities of, and visitors to, the Center from its inception.

SYSTEM IMPROVEMENTS

The Center Project Manager met with the new building manager for LaSalle Partners, Inc., who took over the operation and ownership of the building. The meeting was to discuss the placement of antennae on top of the building and the need for room to house the support equipment. LaSalle had problems accepting our antenna plans. The original plan was to place the Andrews antenna downconverter and air compressor on the 19th floor of the building, but LaSalle had plans to renovate and rent that area as office space. After much discussion, it was decided to house the downconverter and air compressor in an enclosure on the roof. The installation was completed in May, 1985.

The Arlington County Board of Supervisors is required to review any changes to buildings which will alter their appearance. During October, 1985, they approved the installation of two satellite antennae on the condition that they be painted a dark color to match the building. Painting the struts and backside of the antennae posed no problem; however, the white paint on the inside of the antenna dishes and the focal horns is a special type which diffuses sunlight. All common paints reflect sunlight into the focus, especially during the spring and fall equinoxes, and burn out the receivers. A compromise was made with the zoning board which will not impair the operation of the antenna systems.

COMSAT visited the Center after the antennae installation was approved by the Arlington Board of Supervisors and made some measurements of the signal strength of the Andrews antenna receiving the NORESS data.

US Tower Services erected the Regional Seismic Test Network (RSTN) antenna on the roof of the Center on September 4-5, 1984, and the NORESS antenna on the following two days. The cabling from the roof to the 14th floor was also completed at that time. Sandia Laboratories made spectral and signal strength measurements, aligned the antenna, and determined that the signal strength is sufficient to override the interference with AT&T microwave transmissions. Thus satisfactory reception was achieved without further shielding of the antenna.

In August, 1985, two Storage Technology Corporation tri-density magnetic tape drives, two Control Data Corporation 825 megabyte disk drives, and EMULEX tape and disk controllers were acquired and added to one of the VAX computers designated as SEISMO. The two dual-density tape drives formerly on SEISMO were transferred to the PDP-11/44 used as the Communications Interface System for future NORESS/RSTN recording.

In February, 1986, two SUN Microsystems Model 3/160 workstations arrived at the Center. One was scheduled to do classified data processing, and the other was scheduled to do NORESS data acquisition.

In April, 1986, a Celerity dual-processor minicomputer with 16 megabytes of main memory arrived. This system was used for research by scientists and investigators at the Center and at remote sites by using dial-in lines.

OPERATIONS

The attached table gives the uptime and detection statistics for the RSTN stations. It also gives the number of phase arrivals reported at several other seismic data centers. The data were obtained by the Center and included in the archive files. The RSTN site at Cumberland Plateau (RSCP) experienced equipment damage because of lightning and was down from July, 1984, through April 11, 1985. The site at Yellowknife (RSNT) experienced hardware problems and was down from February through April 27, 1985.

ACTIVITIES AND VISITORS

On May 28, 1982 the Center hosted over 80 visitors who had attended the Air Force Office of Scientific Research (AFOSR) Geophysics Review Conference in Hampton, Virginia earlier in the week. Among the visiting attendees were representatives from Norway, Sweden, France, Great Britain, and Canada. Also attending were representatives from the University of Nevada, University of Colorado, University of California, Penn State University, and Southern Methodist University (SMU). The US government was represented by personnel from AFOSR, Air Force Technical Applications Center (AFTAC), Central Intelligence Agency (CIA), Department of Energy (DOE), Arms Control Disarmament Agency (ACDA), United States Geological Survey (USGS), Air Force Geophysics Laboratory (AFGL), Office of Naval Research (ONR), and the United States Naval Research Center (NRC). Representatives from Lincoln Laboratories, Lawrence Berkeley Laboratories (LBL), S-CUBED, ENSCO, and Teledyne Geotech were also in attendance. The guests heard a series of lectures describing the Center's design and operation and saw demonstrations of quality control for the incoming waveform and other seismic data. The capabilities of the Seismic Analyst Station, including the waveform Megatek display, and the mapping color Megatek display, were also demonstrated.

A demonstration of processing seismic data was attended by a Canadian delegation including Dr. Michael Berry, Dr. Peter Basham, and Dr. Robin Hayman on July 27-28, 1982.

Dr. Peter McGregor, who is with the Bureau of Mineral Resources (BMR) in Australia and is also one of the Australian delegates in the Group of Scientific Experts (GSE), spent August 5-6, 1982, at the Center for a general introductory briefing and to discuss ways for the US to exchange seismic data with Australia.

Dr. Robert North spoke on the International Data Center aspects of the Center on January 20, 1983.

In February, 1983, Peter McGregor of BMR in Australia used the Center facilities to work on GSE-proposed experiments and data exchanges.

On March 9, 1983, the Center and DARPA hosted a briefing for Dr. Peter McGregor from BMR in Australia and members of the Australian Embassy. The activities of the Group of Scientific Experts, an overview of the international system for data exchange, and the Australian/US preparation for GSE experiments were discussed. After the briefing the members were given a tour and demonstration.

Dr. Robert Cooper and Dr. Carl Romney of DARPA were given a briefing on the Center and a demonstration of the system's capabilities on May 31, 1983.

On October 21, 1983, visitors from China and the USGS in Reston, Virginia, were given a demonstration of earthquake signal detection and locations. The visitors

were Houde Xu from the Division of Foreign Affairs of the State Seismological Bureau in Peking, Xiaozhai Qu from the Division of Seismological Engineering in Harbin, Yongsong Gong from the Ministry of Urban and Rural Construction and Environmental Protection in Peking, Ping Gu (interpreter) from the State Seismological Bureau in Peking, and Carolyn Hearn from the Office of Earthquake Studies at the USGS in Reston, Virginia.

Dr. Ralph Alewine held a meeting on April 18, 1983, to discuss the Norwegian Regional Array. In attendance, were Dr. Frode Ringdal representing the Norwegian Seismic Array and Mr. F. Dickerson, Mr. J. Pruitt, and Mr. F. Blake representing the Department of Energy.

Frank Grover, John Young, and Peter Marshall from the Blacknest Seismological Research Center in the United Kingdom spent several days in May, 1984, at the Center working, attending meetings, and discussing plans for the 1984 GSE Technical Test.

A GSE Technical Test (GSETT) Workshop was held on August 28, 1984. Beside Center staff, those attending included J. Goldian (USAF), S.G. Allen (USAF), Billy Brooks (AFTAC), Paul Golden (SMU), Donald Springer (LLNL), and Norman Burr (LLNL).

A GSETT briefing was held October 1, 1984. Those attending included Paul Richards (ACDA), Eugene Lanzillo (OJCS), Sheila Buckley (OSD/ISB), T. Etzold (ACDA), Richard Morrow (ACDA), P. Corden (ACDA), F. Dickerson (DOE), and R. Ewing (DOE).

A tour and briefing on the Center for Seismic Studies was given to members of AFTAC/TG and HQ AFTAC on February 7, 1985 by Ann Kerr (DARPA). AFTAC/TG members were Thomas Fauth, Randall Godfrey, Frank Pilotte, and George Rothe. Peter Farkas, John Fergus, David Lehmertz, and G.M. Leies represented HQ AFTAC. Barry Hansen from DIA was also present at the briefing.

The Department of Defense Panel of Nuclear Test Ban Verification held a two-day meeting (February 12-13, 1985) at the Center to discuss Surface Wave Yield Estimation Methods. The panel members attending included Dr. Shelton Alexander (Penn State University), Dr. W. J. Hannon (LLNL), Dr. David Harkrider (Cal Tech), Dr. Eugene Herrin (SMU), Dr. Thomas Jordan (MIT), Dr. Paul Richards (ACDA), Dr. Sean Solomon (MIT), and Dr. Lynn Sykes (Columbia University). Other attendees were Dr. Ralph Alewine (DARPA), Dr. Robert Blandford (DARPA), Col. Theodore Crampton (DNA), Mr. Thomas Eisenhauer (AFTAC), Dr. Robert Gray (AFGL), Mr. Robert Guth (ACDA), Dr. Gerard Leies (AFTAC), Lt. Col. Robert McLaren (DNA), Dr. George Mellman (Sierra Geophysics), Mr. Richard Morrow (ACDA), Dr. John Murphy (S-Cubed), Dr. Edmund Nawrocki (OSD/ISP/VP), Dr. Kenneth Olsen (Los Alamos), Dr. Howard Patton (LLNL), Dr. Frank Pilotte (AFTAC), Dr. Jack Rachlin (USGS), Dr. Carl Romney (SAIC), Dr.

Michael Shore (DNA), Mr. Jeff Stevens (S-Cubed), Dr. Lawrence Turnbull (CIA), and Dr. Donald Westervelt (Los Alamos).

On February 14, 1985, an annual industry briefing seeking sources for research in seismology was held at the Center for DARPA. DARPA representatives were Dr. Ralph Alewine, Dr. Robert Blandford, and Ms. Ann Kerr. Participating contractors included Energy Related Technology, Sprengnether Instruments, ENSCO, Woodward-Clyde, Rondout Associates, EBASCO Services, Inc., Pacific Sierra Research, Earth Technology, Teledyne Geotech, Gould, AFGL, URS Corporation, California Research and Technology, Inc., TERA, Catholic University, S-Cubed, SAIC, USGS, and Belford Instrument Company.

The DARPA Seismic Review Panel met at the Center on June 13-14, 1985. Members attending included Otto Nuttli (St. Louis Univ.), Eugene Herrin (SMU), Shelton Alexander (Penn St.), Thomas Jordan (MIT), Paul Richards (ACDA), Don Helmberger (Cal Tech), David Harkrider (Cal Tech), Ralph Alewine (DARPA), and Robert Blandford (DARPA).

The DARPA Seismic Panel meeting was held at the Center on October 7 and 8, 1985. The major item on their agenda was the completion of the report on yield estimation. Members and consultants attending included Tom Jordan (MIT), Eugene Herrin (SMU), Shelton Alexander (Penn State), Donald Helmberger (Cal Tech), Alan Ryall (SAIC), George Bulin (SAIC), Sean Solomon (MIT), David Harkrider (Cal Tech), and Paul Richards (Lamont).

On October 31, 1985, the Center hosted a visit for the UN Disarmament Fellows. Representatives from Sudan, Somalia, Bolivia, Denmark, Benin, Indonesia, Nigeria, Argentina, Kenya, Mauritania, Mozambique, Burma, United Kingdom, Uganda, Nepal, Mali, and the USA attended. Staff members gave a presentation on the Center's work related to disarmament and demonstrated the use of our equipment.

Frode Ringdal and Rune Paulsen spent time at the Center from December 6-12, 1985, coordinating with Center staff members on details concerning the NORESS Bulletin and the general exchange of information on NORESS. During that week an update and status seminar on the NORESS Array was hosted by Frode Ringdal.

On December 16, 1985, a briefing was held for Dr. Shigeji Suyehiro and T. Yamamoto from the Embassy of Japan. The program consisted of an overview of DARPA geophysical sciences research program, the Center for Seismic Studies, and US activities in GSE. Preliminary results of the GSE Technical Test were discussed and a demonstration of Center capabilities was presented.

Graeme Small from BMR in Australia arrived on February 19, 1986, for a three-week stay at the Center. The purpose of this visit was to work on possible ways to exchange Level 2 data with Australia. He spent this visit learning the Center

systems, hardware, and software and getting hands-on experience using the Center resources.

Frode Ringdal from NORSAR visited the Center on April 28, 1986 to discuss the SUN-3 computer, the details on High Frequency Seismic Element (HFSE) data transfer, and the NORESS satellite data receiving system in Norway.

Listed below are the visitors to the Center and the agency or institution they represented. These visits were for seminars, demonstrations, technical discussions, research and program reviews.

Air Force Geophysics Laboratory

Cipar, J.
Gray, R.
Lewkowicz, J.

Air Force Office of Scientific Research

Best, W.

Air Force Scientific Advisory Board

Bulin, G.

Air Force Technical Applications Center

Brooks, B.
Cardow, J.
Clapper, J.
Clauter, D.
Eisenhauer, T.
Himes, L.
Leies, G.
Robb, J.
Rothe, G.
Trowell, S.
Yacoub, N.

Applied Theory

Trulio, J.

Aramco

Chiburis, E.

Arms Control and Disarmament Agency

Berg, R.
Morrow, R.

Atomic Weapons Research Laboratory

Marshall, P.

Battelle Memorial Institute

Heasler, P.
Nicholson, W.

Bureau of Mineral Resources

Denham, D.
McGregor, P.
Small, G.

Carnegie Institute

Chan, W.
Silver, P.

Central Intelligence Agency

Turnbull, L.

Defense Advanced Research Projects Agency

Alewine, R.
Blandford, R.
Cooper, R.
Kerr, A.
Lasche, G.
O'Leary, P.

Reynolds, R.

Defense Nuclear Agency

Shore, M.

Department of Energy

Dickerson, F.
Pruitt, J.
Blake, F.
Downen, D.

ENSCO

Baumgardt, D.
Broome, P.
Pound, G.
Ryall, F.
Young, G.

Eagle Research

Lane, S.

Georgia Institute of Technology

Dainty, A.

Greenbriar Systems, Inc

Garafola, P.
Norloff, P.
O'Brien, L.

KLD Associates, Inc

Schnitta-Israel, B.
Sherry, J.

Laboratoire Detection Geophysique

Massinon, B.

Lawrence Berkeley Laboratory

Healy, R.
Johnston, W.
Kreps, P.
Scherrer, D.
Yen, A.

Lawrence Livermore National Laboratory

Bonner, B.
Burr, N.
Followil, F.
Hannon, W.
Nyholm, B.
Springer, D.
Tull, J.

Lamont-Doherty Geological Observatory

Richards, P.
Simpson, D.

Lockheed

Sandie, W.

Massachusetts Institute of Technology

Cormier, V.
Duckworth, G.
Ingate, S.
Jordan, T.
Pulli, J.
Solomon, S.

Mission Research

McCartor, G.

National Aeronautics and Space Administration

Flynn, T.

National Oceanographic and Atmospheric Administration

Chinnery, M.

Naval Ocean Research and Devclopment Activities

Ballard, J.
Wagstaff, R.

Norwegian Seismic Array

Fyen, J.
Husebye, E.
Larsen, P.
Mykkeltveit, S.
Paulsen, R.
Ringdal, F.
Spilling, P.

Nuclear Regulatory Commission

Ibrahim, A.
Reiter, L.
Rothman, R.
Sobel, P.

National Defense Research Institute, Sweden

Israelsson, H.
Ohlsson, H.
Slunga, R.

National Science Foundation

Johnson, L.

National Weather Service

Neilon, J.

New York State University

Wu, F.

Office of Naval Research

Heacock, J.
McKisic, M.

Pacific Sierra

Ciervo, T.
Suey, R.
Veith, K.
Watson, B.

Phillips Petroleum

von Seggern, D.

Princeton University

Phinney, R.

Rockwell International

Tittman, B.

Rondout Associates, Inc

Bookbinder, R.
Carter, J.
Sutton, G.

Ruhr University

Harjes, H.

SCRIPPS Institute of Oceanography

Masters, G.
Orcutt, J.

S-Cubed, a Division of Maxwell Labs

Bache, L.
Barker, B.
Bennett, J.
Farrell, W.
Lambert, D.
Murphy, J.
O'Donnell, A.
Shah, H.
Shkoller, B.
Stevens, J.

Science Applications International Corporation

Bache, T.
Romney, C.
Chave, A.

Southern Methodist University

Herrin, G.

Sandia National Laboratories

Corbell, B.
Goldrick, W.
Kromer, R.
Yawakie, R.

Science Horizons

Cherry, T.
Minster, B.
Wang, J.

Sierra Geophysics

Henry, M.
Mellman, G.

St. Louis University

Herrmann, R.
Mitchell, B.
Nuttli, O.

TASC

Sailor, R.

Teledyne Geotech

Anderson, L.
Chang, A.
Der, Z.
Goncz, J.
Gupta, I.
Helterbran, W.
Lees, A.
Marshall, M.
McElfresh, T.
McLaughlin, K.
Rivers, D.
Schirard, J.
Sorrells, M.
Wagner, R.
Whelan, J.

United States Geological Survey

Bufe, C.
Buland, R.
Evernden, J.
Filson, J.
Fluke, J.
Masse, R.
McGan, A.
Pearson, W.
Stewart, R.

Stuart, W.
Wesson, R.
Engdahl, E.

University of California

Flatte, S.

University of California at Berkeley

Johnson, L.
McEvilly, T.
Phillips, J.
Weeks, M.

University of California at San Diego

Berger, J.

University of Colorado

Archambeau, C.
Harvey, D.
Scales, J.

University of Hawaii

Butler, R.
Duennebier, F.

University of Nevada

Ryall, A.
Douglas, B.

University of Paris

Mechler, P.

University of Washington

Smith, S.

Woodward-Clyde

Burdick, L.

TABLE I

RSTN UPTIME IN HOURS
1984

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RSCP	507.8	59.8	25.4	207	296.1	N/A	N/A	N/A	N/A	N/A	N/A
RSNT	508.9	675.5	693.2	257.9	613.3	726.8	479	634	662.2	591	444.3
RSNY	480.1	648	674.3	257.8	580.6	526.8	511.1	655.1	668.5	651.4	538.6
RSON	451	661.5	689.2	249.1	508.7	725.1	364.2	654.6	660.9	655.1	555.3
RSSD	492.2	664.9	686.5	243.5	589.7	691.5	512.5	654.6	669	664	555.5
MAX HRS.	744	720	744	720	744	744	720	744	720	744	744
# OF TAPES	45	55	58	27	50	57	40	58	57	58	46

RSTN DETECTIONS
1984

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RSCP	5496	672	208	3276	3129	N/A	N/A	N/A	N/A	N/A	N/A
RSNT	2554	3031	3631	1253	2081	2050	1364	538	559	721	903
RSNY	1320	2045	2842	1342	2883	2956	1776	871	607	584	409
RSON	2197	2618	2956	1578	2368	2680	897	543	1112	990	788
RSSD	3224	4098	4600	2141	4988	5229	3509	2004	1471	1391	1272

OUTSIDE ARRIVALS
1984

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CANADA	3016	1794	2314	1657	1282	1265	821	1212	2120	2310	2557
NEIS	21274	21431	20799	20568	13012	16822	24977	18020	21908	20004	20140
UK	1313	1165	1234	1149	1463	890	1304	2329	1750	1512	1493
WMO	9697	7700	8104	8060	6893	8675	11756	6990	9353	7345	5266
YKA	954	535	510	578	143	222	155	563	809	777	1236

TABLE II

RSTN UPTIME IN HOURS
1985

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RSCP	N/A	N/A	N/A	474.0	610.4	558.3	623.7	601.5	472.8	578.9	N/A	N/A
RSNT	N/A	34.9	N/A	153.2	617.7	558.3	620.9	711.9	600.9	734.9	N/A	N/A
RSNY	600.5	592.6	503.8	674.2	618.5	558.4	620.7	707.3	599.9	737.5	N/A	N/A
RSON	600.1	591.9	503.6	674.1	618.9	557.4	101.0	401.1	598.1	737.3	N/A	N/A
RSSD	601.1	592.6	503.8	673.5	618.9	543.7	616.7	707.5	533.0	162.4	N/A	N/A
MAX HRS.	744	672	744	720	744	720	744	744	720	744	720	744
# OF TAPES	57	49	50	58	56	50	53	62	53	61	58	61

RSTN DETECTIONS
1985

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RSCP	N/A	N/A	N/A	2457	2531	2586	2713	2882	1974	2269	2423	2398
RSNT	N/A	46	N/A	666	1048	419	327	312	143	992	1099	2395
RSNY	1001	469	661	1010	964	897	1151	1112	816	892	645	425
RSON	918	1218	1216	1302	663	485	157	430	344	455	569	987
RSSD	1597	1384	1615	1626	1463	1187	1473	1763	1226	413	1112	858

OUTSIDE ARRIVALS
1985

	JAN	FEB	MAR	APR	AMY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CANADA	2137	2464	2798	2563	1534	1527	1262	1376	911	2563	N/A	N/A
NEIS	1(21	9554	19296	20733	12275	14060	23500	26189	26458	28364	N/A	N/A
UK	1427	1321	1748	225	3380	1080	2252	1169	396	2155	N/A	N/A
WMO	4900	5030	7192	8676	8458	6025	6445	9105	10243	12947	N/A	N/A
YKA	812	741	760	1065	498	521	172	203	98	1120	N/A	N/A

TABLE III

RSTN UPTIME IN HOURS
1986

	JAN	FEB	MAR	APR
RSCP	725.1	632.3	586.4	446.7
RSNT	728.2	628.1	544.8	654.5
RSNY	715.0	572.3	556.8	667.5
RSON	713.0	585.5	73.0	175.4
RSSD	N/A	628.1	586.4	652.2
MAX HRS.	744	672	744	720
# OF TAPES	61	53	46	46

RSTN DETECTIONS
1986

	JAN	FEB	MAR	APR
RSCP	3121	2651	2762	2471
RSNT	1947	1921	1041	1105
RSNY	1497	1875	1157	972
RSON	1133	1277	119	186
RSSD	N/A	1079	1092	1348

OUTSIDE ARRIVALS
1986

	JAN	FEB	MAR	APR
CANADA	N/A	N/A	N/A	N/A
UK	N/A	N/A	N/A	N/A
WMO	N/A	N/A	N/A	N/A
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